REMARKS

By the present amendment, claims 1 to 5 are pending in the application. Claim 1 is the only independent claim.

Claim Amendments

In claim 1, support for the claim limitation -- said ultrasonic impact treatment of said surface layer providing equiaxial grains in said surface layer -- may be found in the specification at page 6, lines 21 to 26 and page 9, lines 3 to 7.

In claim 1, support for the claim limitation -- at 100 to 500°C for 15 minutes or more -- may be found in prior, now cancelled, dependent claim 6.

§103

Claims 1 to 6 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,338,765 to Statnikov (the " '765 patent") in view of Lu (Materials Science and Engineering, R16 (1996) pp 161-221).

This rejection, as applied to the amended claims, is respectfully traversed.

The Present Invention

The present invention provides a method of production of a steel product with a nanocrystallized surface layer by means of,

(1) subjecting a surface layer of a steel product to ultrasonic impact treatment impacting it by one or more ultrasonic indenters vibrating in a plurality of

directions, with the ultrasonic impact treatment of the surface layer providing equiaxial grains in the surface layer, then

(2) subjecting the surface layer subjected to the ultrasonic impact treatment to heat treatment at 100 to 500°C for 15minutes or more to cause precipitation of nanocrystals.

Patentability

An important feature of the present invention is to apply impact treatment by means of impacting one or more ultrasonic indenters vibrating in a plurality of directions, to provide equiaxial grains in the surface layer followed by heat treatment at 100 to 500°C to cause precipitation of nanocrystals, which is different from the feature of ultrasonic impacting treatment of welded structures or creating a white layer (amorphous layer) at the welded portion as disclosed by the '765 patent. The specification of the present application at page 6, lines 15-30 discloses that:

> In working by impacting making ultrasonic indenters vibrate in only one direction, the structure of the surface layer of the metallic product is developed, the crystal grains do not become equiaxial, and deform to pancake shapes. High angle grain boundaries are not formed.
>
> Therefore, by using a plurality of ultrasonic indenters, making the tips of the ultrasonic indenters vibrate in a plurality of different directions, and impacting the surface layer of the metallic product, formation of texture is suppressed and the grains become equiaxial.
>
> Further, by heat treating at a low temperature the surface layer of the metallic product subjected to the ultrasonic impact treatment, it is possible to make the surface layer nanocrystalline.

For these purposes, the specification further discloses at page 8, line 34 to page 9, line 11 that:

> [A] plurality of ultrasonic indenters 2 are used bundled together. The bundled ultrasonic indenters 2 as a bulk are simultaneously made to vibrate in the vertical direction (Z4) and the horizontal direction (Z5). Therefore, a plurality of ultrasonic vibration apparatuses 1 are provided.

> By making the ultrasonic indenters 2 vibrate simultaneously in the vertical direction and horizontal direction and impact the surface layer of the metallic product, it is possible to suppress the formation of texture and make the crystal grains equiaxial.
>
> Further, after this, it is possible to heat treat the surface layer of the metallic product at a low temperature to cause precipitation of nanocrystals and make the surface layer nanocrystalline.

On the other hand, the '756 patent does not disclose or suggest the characteristic features of the present invention, which provides nanocrystallized surface layer, by vibrating in a plurality of directions to provide equiaxial grains in the surface layer followed by heat treatment at 100 to 500°C to precipitate nanocrystals in the surface layer.

Lu discloses that polycrystalline materials with nanometer-sized grains, termed nanocrystalline materials, can be formed by crystallizing completely amorphous solids under proper heat treatment (annealing) at an appropriate temperature. However, the resultant material obtained by Lu has a nanocrystallized structure in the entire thickness of bulk material. There is no disclosure or suggestion in Lu of how to obtain a nanocrystallized surface layer on a steel product.

This means that Lu only discloses the nanocrystallized structure can be obtained by annealing an amorphous phase of Fe-base alloys to form a nanocrystallized bulk material. However, Lu does not disclose or suggest a steel product having a nanocrystallized surface layer formed by ultrasonic impact treatment of the surface by vibrating in a plurality of directions to provide equiaxial grains in the surface layer followed by heat treatment at 100 to 500°C to precipitate nanocrystals.

Even if the '765 patent and Lu are combined, it is impossible to suppress the formation of texture and make the crystal grains equiaxial in the surface layer, and it is impossible to heat treat the surface layer of the steel product at 100 to 500°C to cause precipitation of nanocrystals and make the surface layer nanocrystalline.

Therefore, the characteristic features of the present invention are not disclosed or suggested by from the combined teachings of the '765 patent and Lu.

It is therefore submitted that independent claim 1, and claims 2 to 5 dependent thereon, are patentable over the '765 patent in view of Lu.

CONCLUSION

It is submitted that in view of the present amendment and foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed for issue.

Respectfully submitted,

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